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GB 1547301 A

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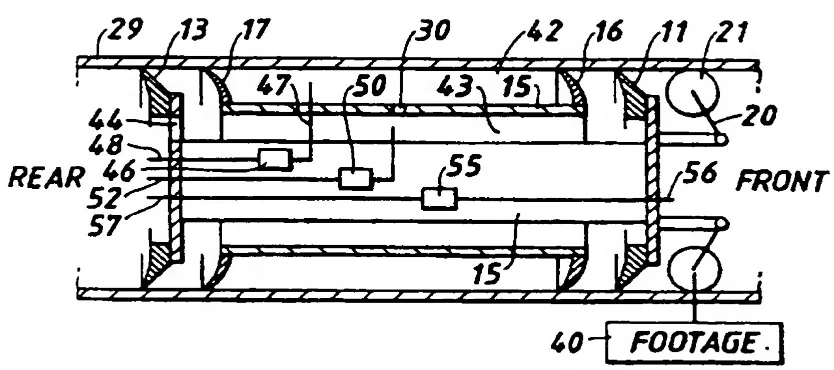
(54) Abstract Title
Pipeline leak detector system

(57) A pipeline leak detector system includes a free flow pig 10 with resilient cups 16 and 17 and body portion 15 defining a test chamber when in contact with the wall of pipeline 29 as it passes under fluid flow through the pipeline. A second chamber is formed between resilient cups 11 and 13 and inner body portion 12 when in contact with the pipeline wall.

Pressure transducers 46, 50 and 55 measure differential pressure at several locations with reference to the fluid at the rear of the pig. Wheels 20 in contact with the pipe allow measurement of the bore diameter and any pig offset to be determined. A footage measurement mechanism 40 provides information on the distance travelled as well as velocity information.

Stored information is downloaded to a computer which is coupled after the pig has carried out a measuring run.

FIG. 2.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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FIG. 1.

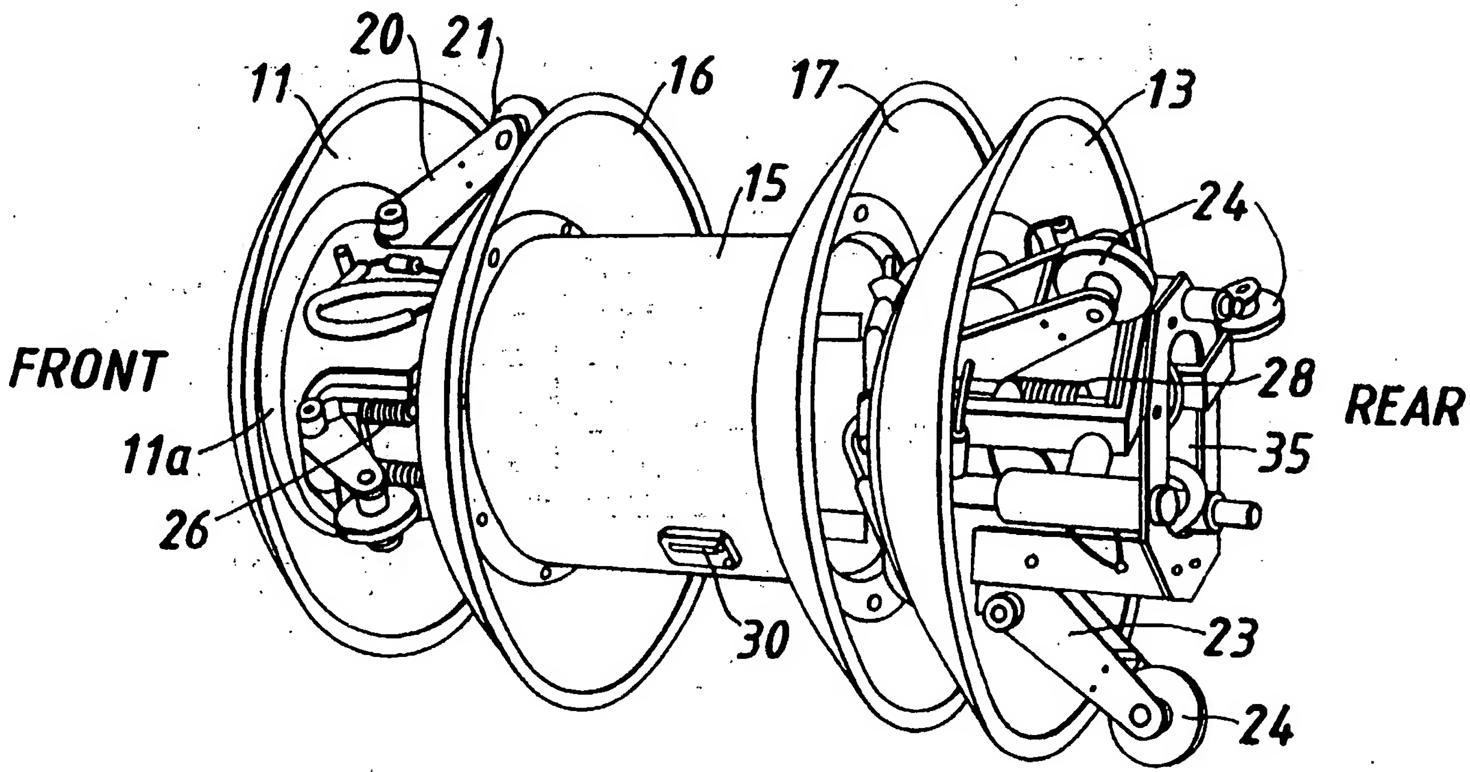


FIG. 2.

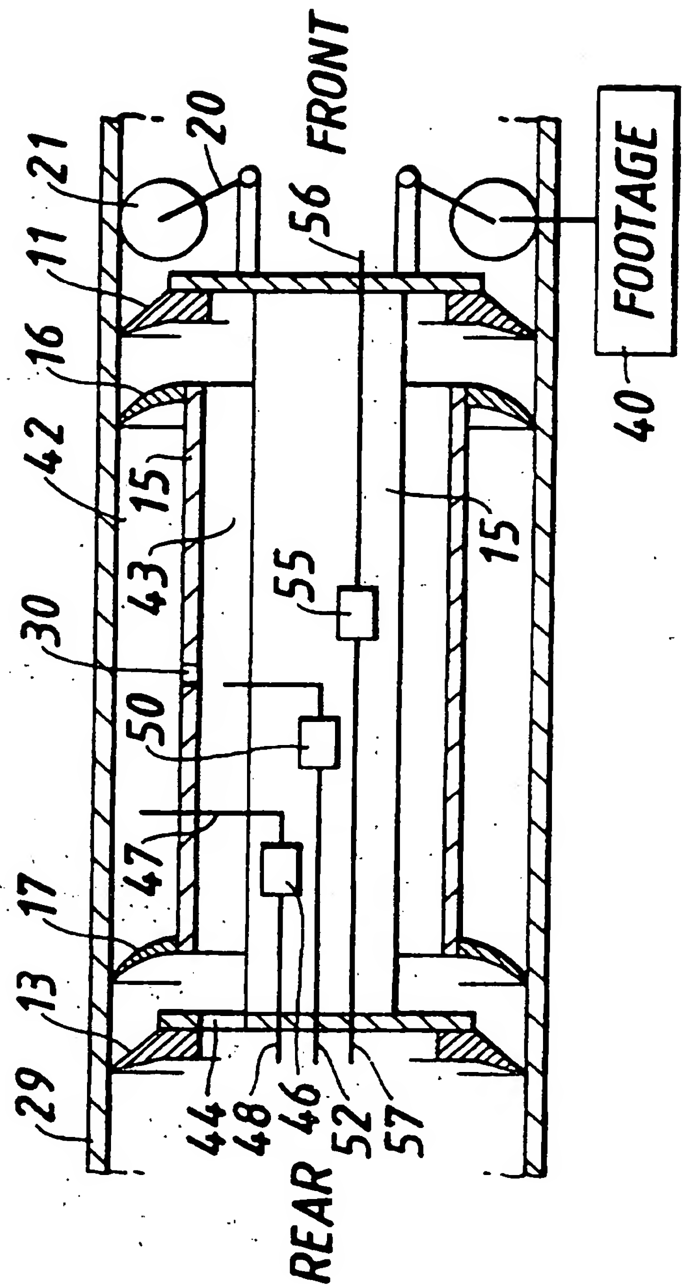
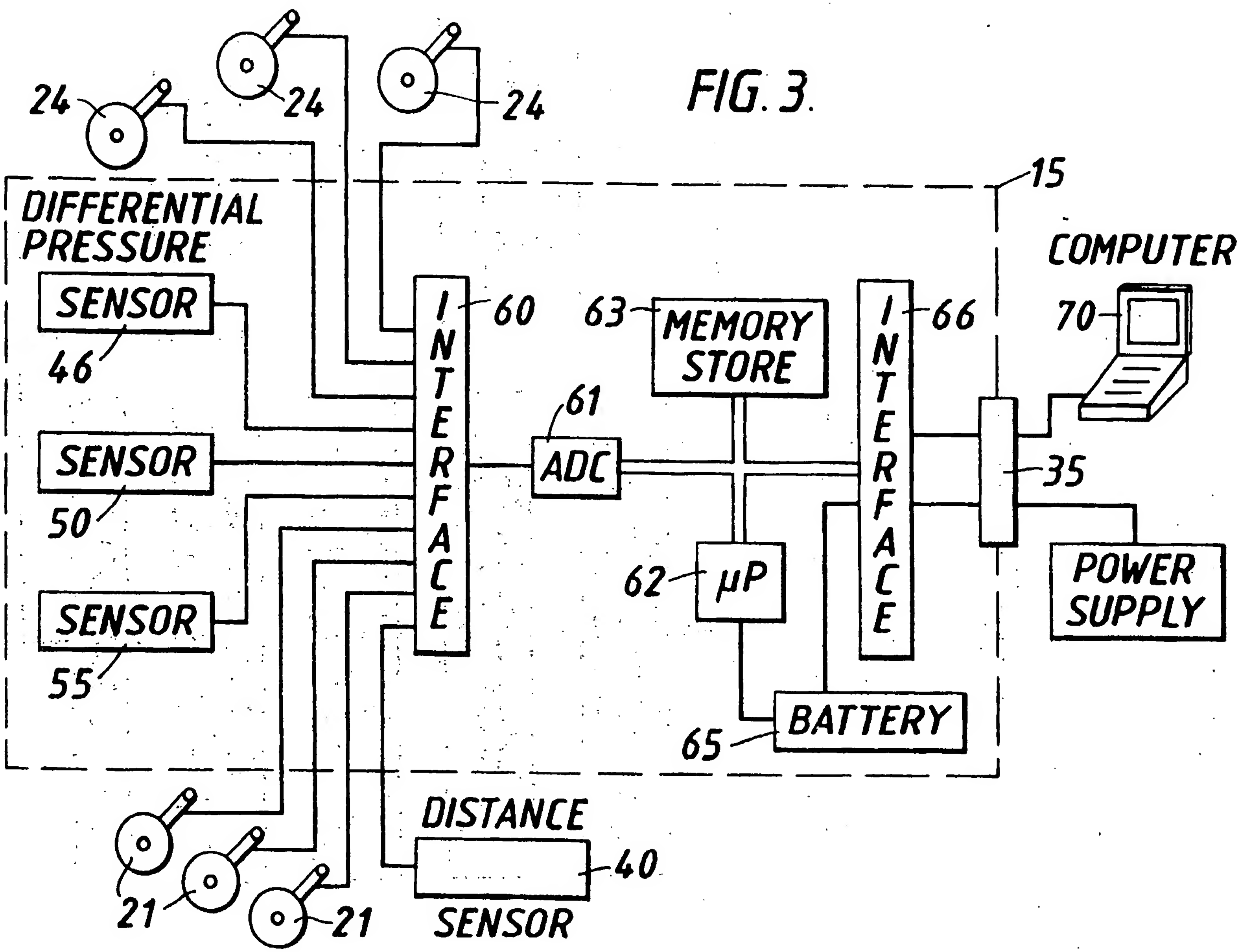

FRONT
REAR
FOOTAGE
40
21
20
56
11
16
42
15
15
15
43
55
30
50
47
17
13
29
44
48
46
52
57

FIG. 3.



24
24
24
15
DIFFERENTIAL PRESSURE
SENSOR
46
SENSOR
50
SENSOR
55
INTERFACE
60
ADC
61
63
MEMORY STORE
62
μP
INTERFACE
66
BATTERY
65
COMPUTER
70
35
POWER SUPPLY
DISTANCE
SENSOR
40
21
21
21

4/5

FIG. 4

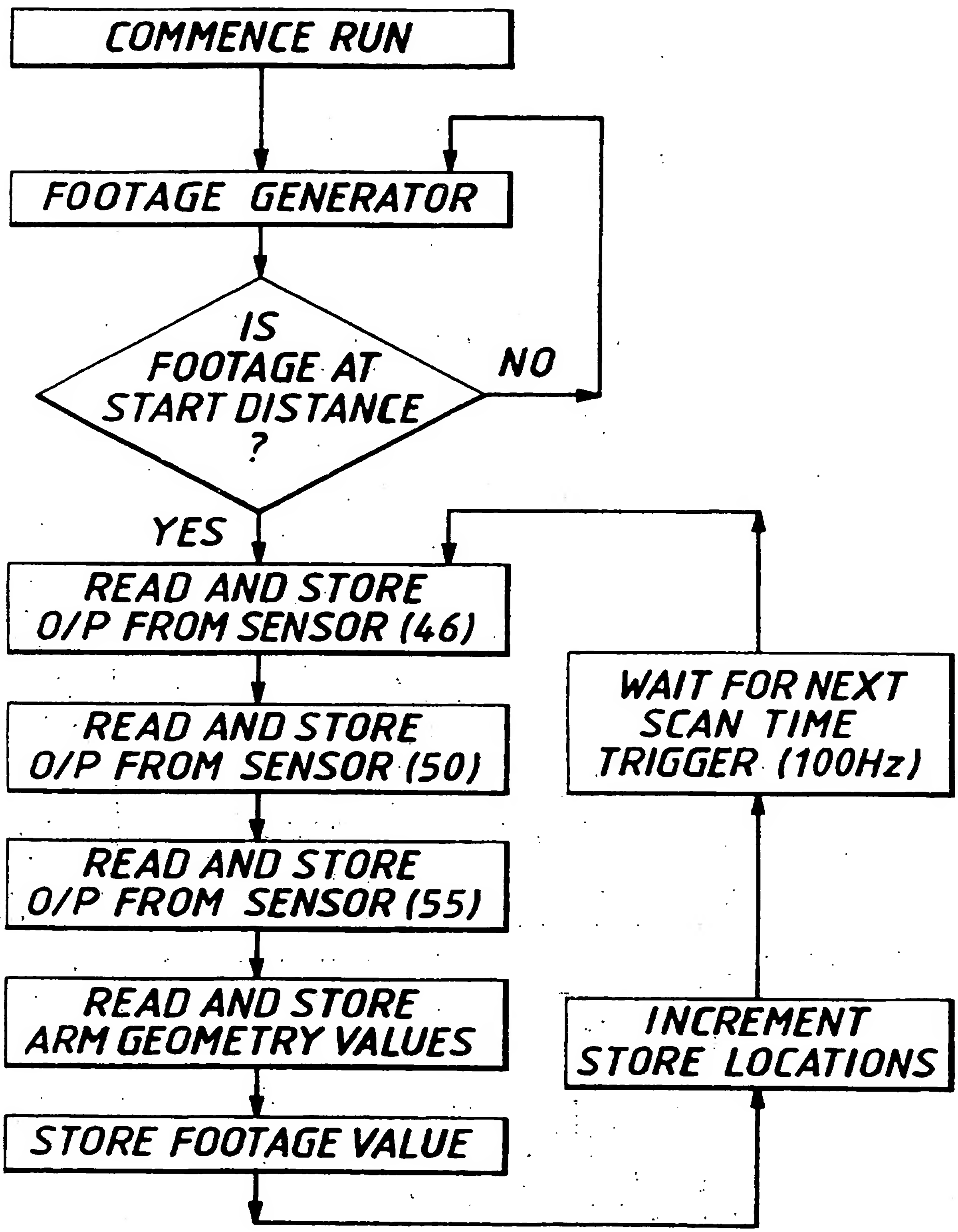
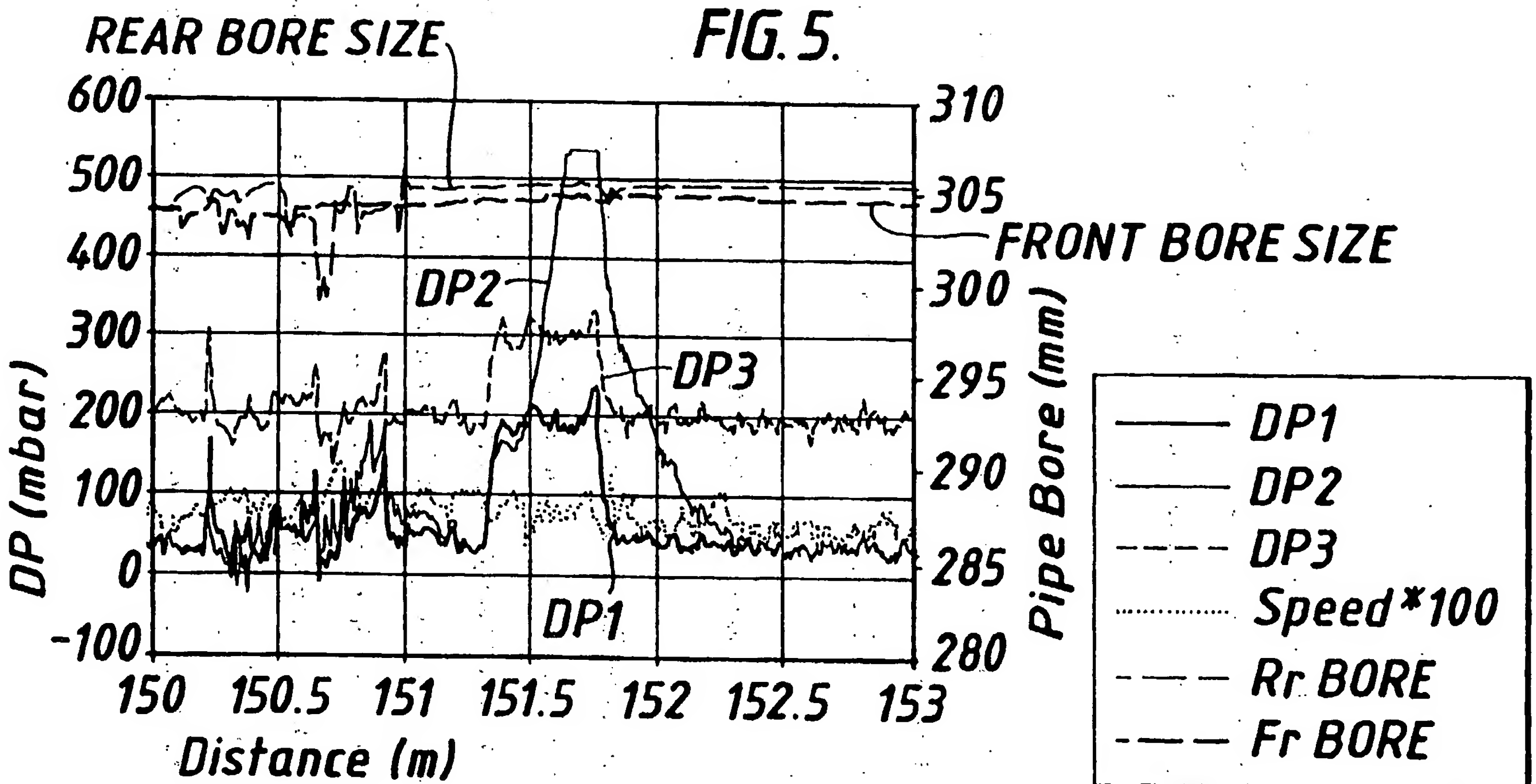

COMMENCE RUN
FOOTAGE GENERATOR
IS FOOTAGE AT START DISTANCE ?
NO
YES
READ AND STORE O/P FROM SENSOR (46)
READ AND STORE O/P FROM SENSOR (50)
READ AND STORE O/P FROM SENSOR (55)
READ AND STORE ARM GEOMETRY VALUES
STORE FOOTAGE VALUE
WAIT FOR NEXT SCAN TIME TRIGGER (100Hz)
INCREMENT STORE LOCATIONS

FIG. 5.



REAR BORE SIZE
FRONT BORE SIZE
600
500
400
300
200
100
0
-100
DP (mbar)
310
305
300
295
290
285
280
Pipe Bore (mm)
150
150.5
151
151.5
152
152.5
153
Distance (m)
DP1
DP2
DP3
Speed*100
Rr BORE
Fr BORE

2327759

PIPELINE LEAK DETECTOR SYSTEM

The invention relates to a pipeline leak detector system for pipelines carrying fluids such as natural gas.

The invention is concerned with providing a device which can be inserted into the pipeline whilst fluid is flowing and will detect leaks due to pipe damage or poor joints for example as it moves through the pipeline, being transported by the flowing fluid.

According to the invention there is provided a pipeline leak detector system comprising:

a device for passing through the bore of a pipeline as fluid flows through the pipe;

means on the device for providing a test chamber with the pipeline internal wall;

means for providing a continuously available orifice from the pipeline to the test chamber from a second chamber;

means for continuously determining the internal pipeline bore size;

means for measuring the differential pressure between two different locations including a first pressure means for measuring the differential pressure between the test chamber fluid and the pipeline fluid external of the device; and

means for determining the position of the device as it travels through the

pipeline.

Further according to the invention there is provided a method of detecting pipeline leaks; including the steps of

passing a device with detectors thereon through the bore of the pipeline so as to be driven by the fluid flow;

measuring a differential pressure between a test chamber, formed between the device and the pipeline wall, and the external fluid in the pipeline;

measuring a differential pressure between a second chamber, formed between the device and the pipeline wall, and the external fluid in the pipeline, the two chambers being linked by a continuously present orifice;

continuously determining the internal bore size of the pipeline; and

determining the position of the device as it travels through the pipeline.

The invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 shows an embodiment of the leak detecting pig for insertion in the pipeline;

Figure 2 shows a schematic view of the leak detecting pig within an existing pipeline to be tested;

Figure 3 shows a block diagram of an embodiment of the data handling and

processing system employed;

Figure 4 shows a flowchart associated with the data acquisition; and

Figure 5 shows graphs associated with typical test results where a leak is present.

The leak detecting pig 10 of Figure 1 is designed to move through a pipeline, e.g. a gas transmission pipeline, with the flow of the fluid as the motivating force. The free flow pig comprises a front cup portion 11 of resilient material mounted on a suspension ring 11a and configured to contact the inner surface of the pipeline through which it is to pass, e.g. a 12 inch pipeline. The cup 11 is fitted to an inner body portion 12 of cylindrical form which terminates at a rear cup portion 13, again of resilient material and mounted on a suspension ring. Between cups 11 and 13 a larger diameter outer body portion 15 carries cups 16 and 17 towards the front and rear respectively again mounted on suspension rings.

Between cups 11 and 16 on the inner body portion 12 there are mounted three spring loaded trailing arms 20 each including an instrumented suspension wheel 21 so that as the bore of the pipe changes, the change will be detected by the moving arm and so the changes can be used to compute circular bore, the amount the pig is off centre (sag) and the angular direction of any sag relative to a datum point. The spring loading

is effected by three tensioning springs 26. One of the wheels 21 is coupled to a footage mechanism (e.g. magnetic sensor) which determines the distance travelled through the pipeline for computation and control purposes.

Likewise on the rear section further arms 23 each including an associated wheel 24 provide data on pipe dimensions and pig sag. The arms are tensioned by means of springs 28. An orifice 30 is provided in the outer body portion 15 to allow a continuous passage to be available between the outer body 15 and inner body 12 for detecting pressure changes as described in more detail with regard to Figure 2 below. The inner body portion 12 which is a sealed pressure vessel for protection, carries the electronics for data measurement and capture and a battery for power requirements. A socket 35 allows information to be entered into the pig via a computer (e.g. laptop PC) prior to passage through the pipeline and to allow recharging of the internal battery. Stored data can be downloaded to the computer after completion of the pipeline run via the socket 35.

Hence the pig is self contained and is driven by the passage of the gas as it flows through the pipeline to give a free flow detection system. Typically it can be used with pipeline bends of 3D and a gas pressure of 500 psi at a flow rate of 1m/s, the latter being the speed of the pig through the pipeline.

Hence by employing a blend of local pressure drop measurements combined with pipe bore mapping, relatively small leaks, typically in the order of 100 scmh can be determined as now explained with regard to Figure 2.

As the pig moves through the pipeline 29, the cups 16 and 17 together with the outer body portion 15 form a test volume chamber 42. The cups 11 and 13 and the inner body portion 15 form an inner chamber 43 coaxial with chamber 42.

The chambers 43 and 42 are connected via the small orifice 30. A small amount of gas within the pipeline can enter the chamber 43 via orifice 44 at the rear of the pig. The main flow of gas causes the pig to be forced along the pipe in a continuous movement.

We have determined that it is advantageous to determine any changes in pipe size via the wheels 21 and associated arms 20 coupled to a transducer (e.g. potentiometer) as well as to determine various pressure changes to cope with gas pressure 'noise' due to turbulence and the movement of the pig. To determine pressure changes three differential pressure transducers 46, 50 and 55 are provided within the inner body portion. They are connected by small pipes to the measurement points.

Hence pressure transducer 46 is connected by pipes 47 and 48 to measure

the differential pressure between the test chamber 42 and the gas at the rear of the pig. Pressure transducer 50 is connected by pipes 51 and 52 to measure the differential pressure between the inner chamber 43 and the gas at the rear of the pig. Pressure transducer 55 is connected by pipes 56 and 57 to measure the differential pressure between the gas at the front of the pig and that at the rear of the pig (i.e. the drive differential pressure).

Footage mechanism 40 (e.g. a magnetic or inductive transducer) will continuously determine the position of the pig as it moves through the pipeline 29 so that the position of any detected leak can be accurately found on dealing with the readings and also provides important velocity information.

The way in which the electronics is configured to handle the information is shown in Figure 3. The electronics boards are contained within the sealed housing 15. The analog electric signals from differential pressure sensors 46, 50 and 55 are received at interface 60 and converted into digital form in ADC 61 under the control of microprocessor 62. The information then passes to store 63 for later retrieval. The store 63 is sufficient to store information from a run of 40 kM or more at a scan rate (e.g. 100 Hz) sufficient to detect a small leak. The footage detector 40 is also connected to interface 60 as are the outputs from the bore measurement arms 21.

A rechargeable battery 65 (e.g. 12V) provides the power source which can

be passed via a regulator (not shown) to provide +/-5v for the system electronics. The pressure differential transducers can be provided with a regulated supply at 12V as appropriate. External access to the electronics is via the socket 35 and interface 66. This allows a laptop PC 70, for example, to download stored information using communicating software as well as to set operational parameters for pig control. A power supply 71 allows recharging of the battery 65 after a run. Hence the computer 70 can, for example, set the distance along the pipeline at which the pig will automatically start to take measurements so as to avoid faulty readings in the vicinity of the entry point, for example, or to avoid duplicating readings already taken on a particular stretch of pipeline. Once the pig is in the pipeline it is self contained and has been disconnected from the computer 70 and needs no umbilicals or other control requirements.

Typical operation of the pig to acquire data is shown on the flowchart of Figure 4. It is seen that the initial part of the run is discarded for the reasons just explained.

On finishing a run, when the pig becomes accessible, the data can be downloaded and the computer 70 will analyse the data to provide a display typically as shown in Figure 5. It can be seen that differential information from all pressure transducers 46, 50 and 56 is displayed against distance in metres. The front and rear bore transducer information is also displayed to give a continuous bore size measure in (mm). In addition the speed of

the pig can also be displayed.

From the graphs DP1 is from transducer 50 taking the differential pressure between the second chamber 43 and the rear of the pig, DP2 is from transducer 46 taking the differential pressure between the test chamber 42 and the rear of the pig, and DP3 is from transducer 55 taking the differential pressure between the front and rear of the pig. It can be seen that at a leakage in the pipe all three transducers will show this, although the highest peak will be from DP2. Analysis of the pressure traces along with bore change traces allows confirmation of a leak as opposed to a spurious signal. Therefore in Figure 5, the graphical information towards the right shows DP2 with a large differential pressure change. At the same position there is no significant bore change so confirming the pressure change is indicative of a leak. By comparison, towards the left of the traces, there is some variation in pressure but observing the bore size measurement it is seen that this also changes indicative of the presence of a flange in the pipeline.

By employing a number of transducers for detecting differential fluid pressures at several locations, 'noise' associated with motion of the vehicle can be overcome so allowing continuous measurement 'on the move' without having to park the pig over the leakage site to allow time for registration of pressure drop. The present arrangement allows small leaks to be determined without interrupting pipeline flow. It is possible to use

the detected information to obtain other parameters under software control, e.g. indication of the size of a leak.

CLAIMS

1. A pipeline leak detector system comprising:
a device for passing through the bore of a pipeline as fluid flows through the pipe;
means on the device for providing a test chamber with the pipeline internal wall;
means for providing a continuously available orifice from the pipeline to the test chamber from a second chamber;
means for continuously determining the internal pipeline bore size;
means for measuring the differential pressure between two different locations including a first pressure means for measuring the differential pressure between the test chamber fluid and the pipeline fluid external of the device; and
means for determining the position of the device as it travels through the pipeline.

2. A system as claimed in claim 1, wherein a second pressure means is configured to measure the differential pressure between fluid in the second chamber and the pipeline fluid external of the device.

3. A system as claimed in claim 1 or 2, wherein a third pressure means is configured to measure the differential pressure of the fluid between the front and rear of the device as it travels in the pipeline.

4. A system as claimed in claim 1, 2 or 3, wherein the test chamber is provided coaxially with the second chamber.

5. A system as claimed in any preceding claim, wherein the means for determining bore size includes a plurality of measuring devices each for determining a size measurement which is combined to determine bore size.

6. A system as claimed in any preceding claim, wherein storage means are provided for holding the detected parameters for later retrieval, said storage means including means connected to the means for determining the position of the device so as to commence storing information when the device has travelled a predetermined distance along the pipeline.

7. A system as claimed in any preceding claim wherein the second chamber in use extends to the internal pipe wall so as to surround the test chamber.

8. A system as claimed in claim 7, wherein the test and second chambers each terminate in resilient means to provide a seal between the device and the adjacent pipe wall.

9. A system as claimed in any preceding claim, including computation means for computing leak information from measured information following the passage of the device through the pipeline, and interface

means for allowing downloading of information from the device to the computation means.

10. A system as claimed in any preceding claim including means for providing a visual display of test parameters including pressure, distance and bore size.

11. A system as claimed in any preceding claim including means for providing visual information on the velocity of the device.

12. A method of detecting pipeline leaks; including the steps of:
passing a device with detectors thereon through the bore of the pipeline so as to be driven by the fluid flow;
measuring a differential pressure between a test chamber, formed between the device and the pipeline wall, and the external fluid in the pipeline;
measuring a differential pressure between a second chamber, formed between the device and the pipeline wall, and the external fluid in the pipeline, the two chambers being linked by a continuously present orifice;
continuously determining the internal bore size of the pipeline; and
determining the position of the device as it travels through the pipeline.

13. A method as claimed in claim 12 including the step of measuring the differential pressure between the front and rear of the device as it travels through the pipeline.

14. A method as claimed in claim 12 or 13 including the step of storing measured information only after the device has travelled a predetermined distance through the pipeline.

15. A pipeline leak detector system substantially as described and with reference to the accompanying drawings.

16. A method of detecting pipeline leaks substantially as described.

The Patent Office

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Application No:	GB 9715394.4	**Examiner:**	Robert MacDonald
Claims searched:	1 - 16	**Date of search:**	30 September 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): G1N (NAAJR, NADF); G1S (SRQ)

Int Cl (Ed.6): G01M (3/00, 3/28)

Other: Online WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	GB 1547301 (INSPECTION TECHNOLOGY DEVELOPMENT)	1,4,5,6,7, 8,10,11,12

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		